AstroPower, Inc.

Partnership "Prime Mover"

US DOE NREL THIN FILM PV PARTNERSHIP

Background

AstroPower was formed in 1983 to develop and manufacture a novel thin-crystalline silicon solar cell on a low-cost substrate. This technology, Silicon-Film™, offers a significant cost advantage over polycrystalline silicon wafers while retaining the high performance and stability of crystalline silicon solar cells. In addition, this process is uniquely capable of producing large-area films, overcoming the size limitations of conventionally grown silicon wafers.

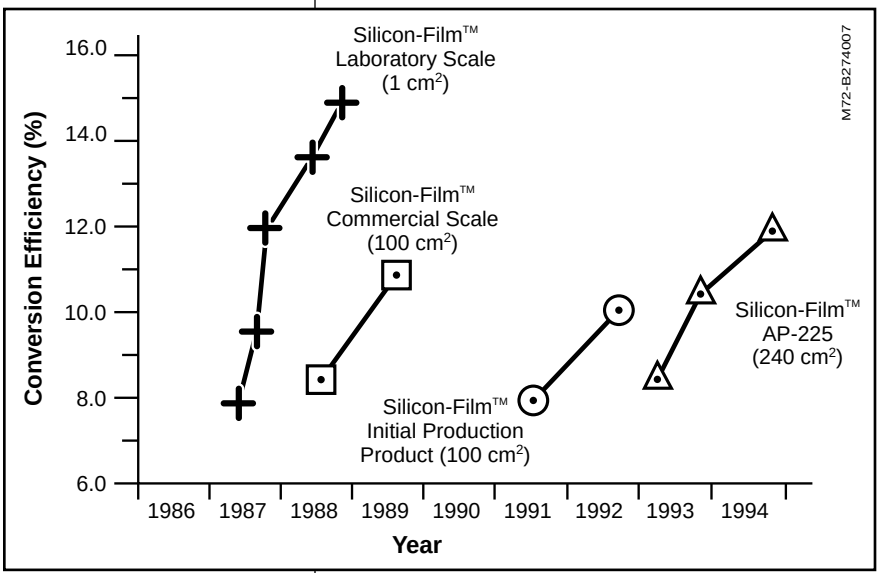

Figure 1. Progress in total-area efficiency for Silicon-Film™ solar cells.

The potential of the Silicon-Film™ technology was first demonstrated in a 1-year project begun in 1987, in which the efficiency of laboratory-scale (1 cm^2), Silicon-Film™ solar cells was improved from 8% to 15%. From 1988 to 1991, development work focused on the transition from laboratory-scale processes and equipment to batch-mode production of 100-cm^2 devices. Throughput started at 5 solar cells per day and grew to 200 solar cells per day. This early work was partially funded by the U.S. Department of Energy's (DOE's) Sandia National Laboratories. In 1991, DOE's National Renewable Energy Laboratory (NREL) awarded AstroPower a 3-year PVMaT contract to assist in the development of a Silicon-Film™ manufacturing technology. During this PVMaT project, AstroPower developed a continuous-sheet production process for 240-cm^2 wafers with a demonstrated production of 1400 wafers per day. The performance history of the Silicon-Film™ technology is illustrated in Figure 1.

In parallel with Silicon-Film™ development, AstroPower decided to enter the PV market with intermediate silicon products. Through the production of single-crystal silicon solar cells, AstroPower established a production facility and work force ready to accept the first Silicon-Film™ product.

Technical Highlights

The PVMaT project made possible the identification and development of the new AP-225 solar cell product, which is 15.5 cm on a side. Due in part to the larger size, AstroPower believes that these new solar cells can be manufactured at a lower cost per unit power than any other commercially available solar cell. The AP-225 solar cell entered the photovoltaics (PV) market in 1994 with the delivery of a 19.3-kW array to a domestic utility customer under the PVUSA program. This installation (Figure 2) represented an important step toward commercialization.

The current Silicon-Film™ machine has a production capacity of 4.4 MW/year. NREL has measured both AP-225 solar cells and corresponding 36-cell modules at that production rate. NREL results include a 240-cm^2 solar cell at 2.8W and a 36-solar-cell module (0.95 cm^2) at 93.0W. A current-versus-voltage (I-V) curve of a 2.8-Watt cell is shown in Figure 3.

AstroPower is using its proprietary Silicon-Film™ technology in the development of a family of three products, as shown in Figure 4. The AP-225 is a first-generation Silicon-Film™ solar cell structure, Product I, incorporating two key features that enable all subsequent generations of solar cell designs: (1) a thin absorber layer that is formed by (2) a continuous in-line growth process. The thin silicon active layer enables low material costs, while the continuous in-line sheet formation process enables high-throughput, low-cost manufacturing.

Future Plans

With the support of funding from the DOE/NREL Thin-Film Partnership, AstroPower plans to employ its Silicon-Film™ technology for the development of a 400-W 4 x 8 ft (2.97-m^2) PV panel product for power applications. The ultimate design will eliminate grid obscuration by integrating the interconnects with the substrate. This advanced product will include the following features:

- a 50-micron-thick silicon layer with 100-micron diffusion lengths
- light trapping due to back-surface reflection
- back-surface passivation
- no grid obscuration
- a 900-cm^2 interconnected submodule.

Figure 2. The Silicon-Film™ AP-225 solar cell modules (19.3 kW) installed at Pacific Gas and Electric Company in Davis, California.

If successful, this approach could lead to a sub-module conversion efficiency as high as 20%. This design, combined with the demonstrated Silicon-Film™ process features low-cost manufacturing, low capital investment equipment, continuous processing, and a low-cost substrate, lead to a projected panel cost of less than $0.64/W. Developing this kind of new technology is one of the key activities of the new NREL/DOE Thin-Film Partnership Program.

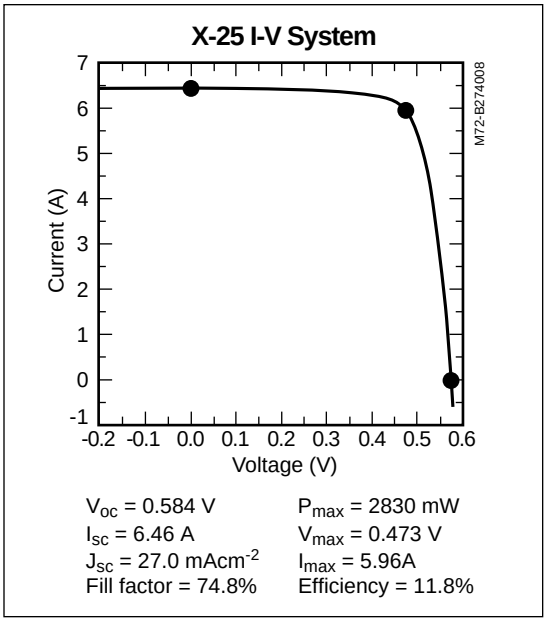

Figure 3. NREL I-V curve of a 2.8-W AP-225 solar cell.

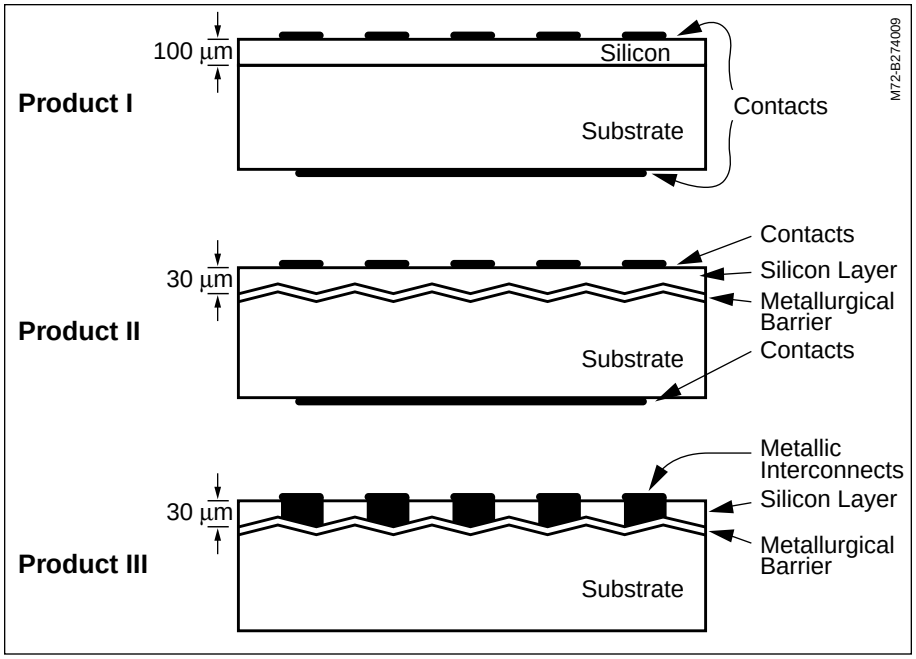

Figure 4. Three generations of Silicon-Film™ products illustrating successive incorporations of advanced design features.

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